

# **International Atomic Energy Consultancy Meeting on Comparison of Curricula in Nuclear Engineering within the ANENT Countries**

**5-9 December 2005, Moscow, Russian Federation**

## ***Meeting Report***

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### **Background**

Following the first coordinating committee meeting organized by the IAEA in Kuala Lumpur, Malaysia, the Asian Network for Education in Nuclear Technology (ANENT) was established in February 2004, to promote, manage and preserve nuclear knowledge; to ensure the continued availability of talented and qualified manpower in the nuclear field in the Asian region; and to enhance the quality of the human resources for the sustainability of nuclear technology. Universities, research centres, government agencies and other institutions involved in nuclear education and training in the region are accepted as participating members of ANENT, and international and regional networks as collaborating members. Currently there are 28 participating institutions from 12 countries (Australia, China, India, Indonesia, Malaysia, Mongolia, Pakistan, Republic of Korea, Sri Lanka, Thailand, Philippines and Vietnam) and 6 networks as collaborating members.

The overall objective of the ANENT is to develop a new partnership for cooperation in human resources development and research in nuclear technology as a key strategy for capacity building, nuclear infrastructure development and better use of available information resources.

### **Purpose, objectives and topics of the Meeting**

There exist large differences between the levels of development in nuclear technology and applied nuclear sciences in Asian countries. This makes it difficult to develop regional reference curricula in nuclear technology and to promote credit transfer and mutual recognition of degrees within the region, which are the central tasks of the ANENT Activity 4. The Meeting was convened for studying and discussing the existing differences in nuclear education curricula. The intention was that the Meeting would agree on proposed reference curricula and thus accelerate the implementation of ANENT Activity 4. It was hoped that the fruits of the discussion at this meeting would also serve as pilots for embarking on reference curricula for other subjects in the future.

The objective of the Meeting was to evaluate and analyse curricula in nuclear engineering in the ANENT member institutions, and draft recommendations for establishing reference curricula and mechanisms for transferring credits and recognising mutual degrees. Participants were expected to reach a consensus in comparison and assessment of the curricula in use and draft a series of reference curricula.

### **Organization**

The Meeting was organized by the International Atomic Energy Agency and hosted by the Moscow Engineering Physics Institute (MEPhI), Moscow, Russian Federation. Its

participants of the Meeting acknowledged MEPhI's great support in the Meeting organization and their warm hospitality.

### **Consultants' starting points of views:**

1. Some of the ANENT member institutions have already developed their own curricula which satisfy the requirements and demands of the other member countries and their institutions.
2. The reference curricula to be proposed should be useful and practical so that most of its contents can really be utilized by the ANENT member countries.

### **Main requirements for the ANENT Reference Curricula in Nuclear Engineering:**

1. The ANENT Reference Curricula in Nuclear Engineering should provide the students with the following blocks of knowledge:
  - a) Block of Basic Knowledge:
    - a1- Basic Knowledge in various fields relating to nuclear engineering education;
    - a2- Basic Knowledge in nuclear field;
  - b) Block of Specific Knowledge essential for introducing and using nuclear power- and non-power engineering in ANENT member countries;
  - c) Block of Advanced Knowledge (from medium- and long-term perspectives).
2. For the purpose of facilitating credit transfer and mutual recognition of degrees (as the long term goals of the ANENT), the Reference Curricula should contain a large number of subjects based on the common interests of the ANENT member countries.
3. The curricula subjects should cover a wide range of sophistication so that they can also meet the needs of member countries which are already highly advanced in nuclear science and technology.
4. It is desirable to describe the subjects of the Reference Curricula in as much detail as possible.

### **Reference Curricula in Nuclear Engineering**

The Meeting aimed to develop a set of reference curricula of common interest to the ANENT member institutions for the purpose of nuclear engineering education. It was recognized that the reference curricula should take into account the different educational system of each country. The educational system in Asian countries were examined and compared with those in European and North American countries. Useful pointers were derived from the evolving educational system in Russia as expounded by the professors from MEPhI.

### **Structure of Reference Curricula**

First it was agreed that the reference curricula should target the appropriate knowledge level of Master of Science. Nuclear education requires prior knowledge in science and technology. An indispensable prerequisite should be a Bachelor's degree in a science course

such as physics, chemistry, mathematics or any branch of engineering, including nuclear engineering. Secondly it was recognized that the specialties in Nuclear Engineering comprised the following three distinct spheres: 1) power production, 2) non-power applications such as industrial use of isotopes, medical use of isotopes and biotechnological uses, and 3) fusion technology. Therefore the reference curricula should aim at issuing the following three ANENT Master's degrees.

1. Master's Degree in Nuclear Engineering (Power Application)
2. Master's Degree in Nuclear Engineering (Non-Power Application)
3. Master's Degree in Nuclear Engineering (Fusion Technology)

## **Proposed Reference Curricula for the ANENT MDNE**

The proposed Reference Curricula consist of the following five areas. Depending on the combination of credits acquired in these areas, the ANENT Master's Degree will be issued in the three specialties mentioned above.

- 1) Common area covering all essential subjects which can be taken by both Power and Non-Power Application/Engineering students (C1),
- 2) Introductory area, covering all basic subjects which can be taken by both Power and Non-Power Application students (C2),
- 3) Specific area for Power Application/Engineering students (S1),
- 4) Specific area for Non-Power Application/Engineering students (S2),
- 5) Specific area for Fusion Technology/Engineering students (S3). (This area may be developed from medium- and long-term perspectives)

### **1. Common Area (C1)**

The Common Area (C1) contains the following four subjects which are essential for all the specialties. Not all the subjects are compulsory; some of them are optional. The minimum required credits for the ANENT Master's Degree will be specified at a later stage (probably 2 or 3 subjects). The Common Area should not exceed 25% of the total required credits.

1. Advanced Mathematics for Nuclear Engineering
2. Advanced Numerical Analysis
3. Advanced Computer Applications
4. Engineering Physics (including lasers and accelerators)

### **2. Introductory Area (C2)**

The Introductory Area (C2) should be prepared for those students who have no nuclear science and technology background in their bachelors' degree. The subjects stated below are not compulsory except two "Cores"; the others can be taken on an optional basis. The minimum required credits for the ANENT Master's Degree will be specified at a later stage (probably 2 or 3 subjects). This area should not exceed 25% of the total required credits. The proposed Reference Curricula in the Introductory Area consist of the following subjects:

5. Introduction to Nuclear Engineering (Core)
6. Radiation Detection and Measurements (Core)
7. Radiation Safety and Shielding
8. Power Plant Instrumentation
9. Nuclear Safety
10. Nuclear and Reactor Physics
11. Health Physics
12. Nuclear Heat Transfer
13. Nuclear Power Plants Engineering
14. Materials Science in Nuclear Engineering

### **3. Specific Area (Nuclear Power, S1)**

This Specific Area (S1) covers nuclear power-generation applications. Some of these subjects can also be used for Ph. D students. The minimum required credits for the ANENT Master's Degree should be specified at a later stage. This area should not exceed 50% of the total required credits. The proposed S1 Reference Curricula consist of the following subjects:

15. Neutron Transport Theory
16. Reactor Kinetics
17. Advanced Nuclear Heat Transfer
18. Nuclear Reactor Numerical Analysis
19. Nuclear Fuel Cycle and Non-Proliferation
20. Power Reactor Design (System Engineering)
21. Advanced Nuclear Safety
22. Probabilistic Safety Analysis
23. Strategy and Infrastructure for Nuclear Power
24. NPP Control and Instrumentation
25. Nuclear Regulation
26. Nuclear Material Engineering

### **4. Specific Area (Nuclear Non-Power, S2)**

This Specific Area (S2) is meant for nuclear non-power application students. The curricula may cover radiation applications for industrial, agricultural, and medical purposes as well as radio-medical physics including follow-up discussions/consultations. This area should not exceed 50% of the total required credits. The proposed S2 Reference Curricula consist of the following subjects:

27. Radiation Protection and Shielding
28. Application of Radioisotope and Radiation Sources

29. Non-Destructive Testing
30. Nuclear Imaging
31. Radioactive Waste Management
32. Advanced Health Physics
33. Applied Radiation Measurements

## **5. Specific Area (Fusion, S3)**

This Specific Area (S3) covers Fusion Technology. The proposed curricula aim to introduce and help students to develop plasma-based methods and other various aspects relating to nuclear fusion energy. This area should not exceed 50% of the total required credits. The S3 Reference Curricula consist of the following subjects:

34. Advanced Laser Application Engineering
35. Advanced Quantum Engineering
36. Plasma Diagnostics
37. Plasma Processing Analysis
38. Advanced Plasma Engineering
39. Nuclear Spectroscopy
40. Thermonuclear Fusion Engineering

## **ANENT Master's Degree in Nuclear Engineering (MDNE)**

In order to ensure a high level of education in nuclear engineering and to facilitate transferring credits and mutual recognition of degrees within the ANENT member countries, the participants in the Meeting agreed to propose establishing an **ANENT Master's Degree in Nuclear Engineering (ANENT MDNE)**. The full curricula required to issue this degree should be composed principally of the subjects included in the Reference Curricula in Nuclear Engineering approved by the ANENT members. The credits for the **ANENT MDNE** can be collected from all "ANENT-recognized" institutions, and the degree will be granted by the **ANENT MDNE** Certification Committee, which is also proposed to be established. Based on the Reference Curricula in Nuclear Engineering, the future **ANENT MDNE** Certification Committee is expected to develop a set of requirements to be fulfilled by applicants.

The students can perform their studies in one or more educational institutions located in different ANENT member countries. National institutions can grant their Master's Degree in Nuclear Engineering based upon their procedures and recognition of credits in their respective countries, but it is expected that the national approaches will be made consistent with the ANENT basic philosophy and be based on the ANENT Reference Curricula for MDNE.

The **ANENT MDNE** will be granted by ANENT, on behalf of its members, and will be recognized in the countries of the region as a proof that a holder of this degree has obtained a master level degree corresponding to the level accepted and recognized by all the ANENT members.

The Meeting also suggested that the MDNE programmes in ANENT educational institutions be approved (or certified) by the ANENT Certification Committee in order to streamline the process of obtaining the ANENT MDNE for applicants. The participants understood that this certification would not be obligatory and that it represented a wish of the ANENT members so as to consolidate their efforts in improving nuclear education in the region.

## **Conclusions and Recommendations**

### **Conclusions**

1. The consultants and participants of the Meeting have been acquainted with the following:
  - a. Curricula on nuclear science and nuclear engineering of the host country – Russia, as well as of the Republic of Korea, India and Vietnam;
  - b. Nuclear education activities of the World Nuclear University (WNU);
  - c. Nuclear education facilities at Moscow Engineering Physics Institute (MEPhI).
2. The consultants and participants of the Meeting have conducted discussions and analysis on the curricula in nuclear engineering education in the Region.
3. Main efforts were focused on developing a draft of the ANENT Reference Curricula for Master's Degree in Nuclear Engineering. The skeleton of the first draft of the Reference Curricula was created.
4. The idea about the ANENT Master's Degree in Nuclear Engineering (ANENT MDNE) was discussed. Realization of such degree would strongly and directly enhance and heighten the regional educational level in nuclear engineering in the near future. It is also expected to facilitate credit transfer and mutual recognition of degrees within the ANENT member countries in line with the ANENT's long term goals.
5. The consultants and participants of the Meeting expressed their heartfelt thanks to the collective of Moscow Engineering Physics Institute (MEPhI) – the Host Organization - and to all the members of the Local Organizing Committee of the Meeting, as well as to the ANENT Scientific Secretary, for the warm atmosphere and perfect conditions provided for the success of the Meeting.

### **Recommendations**

The consultants and participants of the Meeting have agreed to recommend:

1. To conduct an intensive exchange of opinions between experts and educators in the ANENT member countries to develop the ANENT Reference Curricula for Master's Degree in Nuclear Engineering (MDNE) based on the skeleton of the draft.
2. To start more extensive discussion about the idea of the ANENT MDNE and how to realize it effectively and reasonably as soon as possible.

3. To discuss about ANENT Activity 4 at the next Meeting of the ANENT Coordination Committee.
4. To continue requesting the IAEA to fund a TC Project for ANENT MDNE in the near future or to finance the existing ANENT Project incorporating the ANENT MDNE.

## **Attachments**

1. List of participants
2. The first draft of the ANENT Reference Curricula for Master Degree in Nuclear Engineering

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